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Automated Escape Guidance Algorithms for An Escape Vehicle

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An escape vehicle was designed to provide an emergency evacuation for crew members living on a space station. For maximum escape capability, the escape vehicle needs to have the ability to safely evacuate a station in a contingency scenario such as an uncontrolled (e.g., tumbling) station. This emergency escape sequence will typically be divided into three events: The first separation event (SEP1), the navigation reconstruction event, and the second separation event (SEP2). SEP1 is responsible for taking the spacecraft from its docking port to a distance greater than the maximum radius of the rotating station. The navigation reconstruction event takes place prior to the SEP2 event and establishes the orbital state to within the tolerance limits necessary for SEP2. The SEP2 event calculates and performs an avoidance burn to prevent station recontact during the next several orbits. This paper presents the tools and results for the whole separation sequence with an emphasis on the two separation events.

The first challenge includes collision avoidance during the escape sequence while the station is in an uncontrolled rotational state, with rotation rates of up to 2 degrees per second. The task of avoiding a collision may require the use of the Vehicle's de-orbit propulsion system for maximum thrust and minimum dwell time within the vicinity of the station vicinity. The thrust of the propulsion system is in a single direction, and can be controlled only by the attitude of the spacecraft. Escape algorithms based on a look-up table or analytical guidance can be implemented since the rotation rate and the angular momentum vector can be sensed onboard and a-priori knowledge of the position and relative orientation are available. In addition, crew intervention has been provided for in the event of unforeseen obstacles in the escape path.

The purpose of the SEP2 burn is to avoid re-contact with the station over an extended period of time. Performing this maneuver properly requires knowledge of the orbital state, which is obtained during the navigation state reconstruction event. Since the direction of the delta-v of the SEP1 maneuver is a random variable with respect to the Local Vertical Local Horizontal (LVLH) coordinate system, calculating the required SEP2 burn is a challenge. This problem was solved using a neural network as a model-free function approximation technique.